Compressed Air

DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

VOL. III. NEW YORK, MAY-JUNE, 1898. NO 3-4

COMPRESSED AIR CARRIAGE.

Compressed Air.

A MONTHLY PUBLICATION DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

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The installation of a large compressed air plant on West 23rd Street, New York, for the purpose of supplying power to street cars on the 28th and 29th Street lines, is an important event in compressed air history. It is also a hopeful indication that pneumatic traction may become of useful commercial interest.

Certain facts may be asserted with confidence. The American Air Power Company has arranged with the Metropolitan Traction Company to install an air compressor of 1000 h. p. capacity for street car purposes. The Air Power Company has also contracted with certain well known manufacturers of machinery to build this plant. Looking into the details of the case we find that this installation is to be unlike any that has heretofore been brought to public notice in America. In the first place the business is in the hands of the Traction people, who have the experience and the money to develop this new system for street car propulsion. In the second place, this case appears to have been wisely considered by business men, and an order given for a plant of machinery which represents the best that modern mechanical science can devise. The makers are not restricted to anything on lines of economy or on the plea of temporary use, but are asked to build the best machinery that can be devised for this purpose, and in a unit so large that it is reasonable to expect a condition of economy in the production of compessed air which has not heretofore been reached.

This appears, in a measure, to be a development of pneumatic traction experiments which have been carried on at infrequent intervals and in a rather erratic manner since 1879. Efforts twice made by the Hardie motor to find a place on the Elevated Railroad should not be belittled in the light of present knowledge, because, while ill-advised from a business standpoint, they were important mechanically in that it was demonstrated that a train of cars could be handled with reasonable economy by an air motor.

Pneumatic experiments on the elevated road cannot be called mechanical failures; hence the results do not reflect discredit either upon compressed air or upon the engineers engaged in them Their chief weakness was in attempting to develop an important pneumatic application by beginning at the top. The Judson system which was installed at Washington, D.C., attracted attention to pneumatic traction, and suggested, perhaps, some of its possibilities. The experiments with the Mekarski system had a like influence, but this system did more than the other in that it confirmed the confidence of engineers in the storage system for pneumatic traction. The work of Jarvis, Parke, Hoadley and Knight was in the nature of an advance, developing new ideas and profiting by earlier experiences of others. One of the difficulties against which pneumatic traction has had to contend, is that there was too much speculation in it. Time and money were spent in selling rights, in developing patents and in the organization of companies, which might have been spent

to better advantage in the equipment of a small street railroad. The common error has been made in supposing that compressed air was the coming power for street railroads, and that it would replace all others. Compressed air is only one among other useful means by which street cars may be driven. It has its place alongside of electricity, and perhaps closely associated with it, but it is not at all likely to drive electricity out of the field.

The American Air Power Company is a consolidation of all American pneumatic traction interests. This company controls most of the patents on this subject. On its staff are the engineers who have had the experience, and on its Board of Directors are men who know the street car business. Mr. H. H. Vreeland, President of the Metropolitan Traction Company, has a hand in this matter in no uncertain way. Mr. Vreeland has never been known to be windy on this or any other subject. He thinks, perhaps, that there may be a field for compressed air on cross-town service, where the runs are shorter, and where the independent motor will be useful in traveling on different tracks, and where its use will not involve a large expense in construction, which is necessary when the overhead trolley cannot be used.

It is perhaps true that the officers of the Traction Company are not yet confident believers in the success of pneumatic traction, but those who have greater confidence than this should be well pleased at the opportunity which will here be afforded to prove this case under the eyes and supervision of President Vreeland, supported by men who have at least thus far shown a willingness to pay for a demonstration which is not restricted for want of funds and which has at least been started in a way that indicates permanence.

Compressed Air Motors.

The compressed air system has been adopted for the 28th and 29th street cross-town lines of New York, by the Metropolitan Street Railway Co. During the past three years strong efforts have been made to secure for this system a permanent franchise for its establishment.

Extended experiments in connection with the Hoadley-Knight system have been conducted by the Metropolitan Railway Company, of which Mr. H. H. Vreeland is President. Over eight years ago it was seen that of necessity, some efficient and economical method of operating street railways in New York would have to be adopted, and gas engines, ammonia motors, compressed air, electric storage batteries and electricity as a constant current as used in the overhead trolley system, were all considered. New York has stoutly refused to have the overhead system, and it was necessary for his company to go ahead and find some other system. Eminent engineers were sent abroad and the inquiries brought forth some 2600 replies offering many schemes. Some had merit, but after giving them consideration the company was so to speak, in on the air ; and as Mr. Vreeland himself says : " We are latter day saints in the compressed air proposition."

No such exhaustive research has ever been made in the history of traction. It was not conducted solely in the interests of compressed air, but in the interests of capital invested in plants, rapid transit for the traveling public, and the comfort and safety of patrons. The experiments and tests of steel tubes alone being of a most exacting nature. Large numbers of the best tubes were purchased and tested to destruction. This system did not dawn on the Metropolitan Street Railway Company like a sunburst. It grew and developed, and finally became what it is, and its adoption leaves no doubt in the mind of the company as to the success of the system both in regard to its efficiency and economy and other advantages commonly conceded to compressed air. At the same time the Hoadley-Knight system was being tried on the Lenox Avenue line, New York, and on the Eckington & Soldiers' Home Railway at Washington, D. C., but the results desired from the experiments were so exacting that the chance for their adoption seemed for a time hopeless.

The Hoadley-Knight System.

The compressed air motor cars for this system were designed by Mr. J. H. Hoadley and Mr. Walter H. Knight. In general construction the motor resembles an electric motor—iron clad, and resting with one end upon the axle, to which its crank shaft is geared.

The unsatisfactory results attending the use of side rods and exposed machinery, in connection with the electric motor, were, of course, well known, and it was realized at once that in any form of air motor it was essential that the moving parts should be enclosed in a case where they could run in oil, free from dust, and where they would lubricate themselves continuously without the attention of the operator. It also seemed extremely desirable to continue the use of standard street car wheels, axles, trucks and car bodies, as these have all reached a standardized form which is known to insure the least expense of maintenance.

Owing, also, to the limited intelligence of the motorman, and the necessity of more prompt control than is had with steam locomotives, it was considered necessary to develop a controller, which could be operated by a single handle to perform all the various functions of the controller in their proper sequence, without requiring thought on the part of the motormen. These three features of iron clad motors, running in oil, standard street railway rolling stock and single handle controller, were therefore made the distinctive features of the Hoadley-Knight system, which may be described more in detail as follows :

Motor Cylinders and Mechanism.

On each axle is mounted an iron clad motor, having two cylinders and cranks at right angles. One motor has two high pressure cylinders, 3½ ins. diameter and 6 ins. stroke, and the other motor has two low pressure cylinders, 7 ins. diameter and 6 ins. stroke. Upon the crank shaft is a pinion, about 9 ins. in diameter, meshing into a 23 in. gear wheel mounted on the middle of the axle; the axle is straight, as used for electric motors, and the wheels are ordinary street car wheels. The motor consists essentially of a cast iron case or basin, to which the two cylinders are bolted and in which all the moving parts, the piston rods, crossheads, connecting rods, cranks, gears, valve rods, eccentrics and

FIG. 1—COMPRESSED AIR MOTOR CAR.

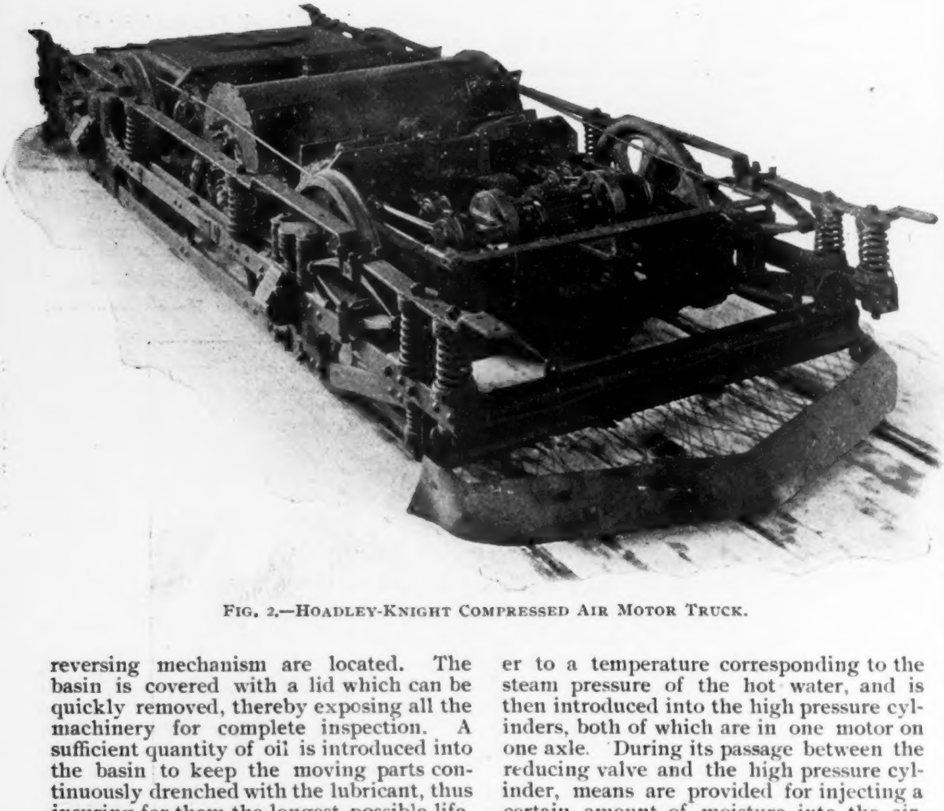


FIG. 2.—HOADLEY-KNIGHT COMPRESSED AIR MOTOR TRUCK.

reversing mechanism are located. The basin is covered with a lid which can be quickly removed, thereby exposing all the machinery for complete inspection. A sufficient quantity of oil is introduced into the basin to keep the moving parts continuously drenched with the lubricant, thus insuring for them the longest possible life, and reducing to a corresponding degree the maintenance account.

Air Reservoirs and Heater.

The air reservoirs, in the shape of seamless steel bottles, are under the seats of the car, and a pipe leads from them to a combined reducing and throttle valve, which reduces the storage pressure to the working pressure. The pipe before reaching the reducing valve passes around the heater, so that the air can receive sufficient heat to prevent freezing any moisture that may be in it.

The heater consists of a seamless flask charged with hot water under a pressure of from 150 lbs. to 250 lbs.

What the Air Does.

The air on leaving the reducing valve passes through a coil kept hot by the heater to a temperature corresponding to the steam pressure of the hot water, and is then introduced into the high pressure cylinders, both of which are in one motor on one axle. During its passage between the reducing valve and the high pressure cylinder, means are provided for injecting a certain amount of moisture into the air, this having been found to give certain advantages, as will be described later. In exhausting from the high pressure motor, the air is again heated and passes through the low pressure motor on the other axle, from which it escapes through a muffler into the atmosphere. By having one motor high pressure and the other motor low pressure, undue slipping of the wheels is prevented, as when the high pressure wheels slip the low pressure motor gets more air and more pressure, and the back pressure from the receiver tends to stop the slipping. When the low pressure motor slips its wheels, it draws down the receiver pressure and thereby weakens itself, correspondingly increasing the strength of the non-slipping motor. The direction of the flow of the air is shown in Fig. 3 where *R R* are the air reservoirs, *V* the reducing valve, *H* the heater, *M M* the motors.

Durability.

Twelve months' operation has demonstrated that these motors are highly efficient and exceedingly durable, all of the original parts being still in use. The manufacturers estimate that, making a liberal allowance for the wear and tear that must occur, which, in the case of the more rapidly wearing parts, has been measured, the maintainance per car mile can be figured at not more than one cent, which compares favorably with that of the electric motor.

Weight of Cars.

The weight of the standard Hoadley-Knight air car is tabulated as follows:

Car body..............	6,000 lbs.
Trucks...............	4,500 "
Air reservoirs..........	3,000 "
Heater................	500 "
Motors (each 1500 lbs.)	3,000 "
Controlling apparatus..	400 "
Piping................	150 "
Total............	17,550 "

one-half cent per horse power hour, including all power house charges. To this must be added the cost of the hot water for reheating, which is given by the engineers of the system as one mill per car mile. The motive power expenses per car mile on this basis are therefore estimated as follows:

Cost Per Car Mile of Motive Power.

3½ h.p. hours at ½ cent.... ...	$.0175
Hot water for reheating........	.001
Maintenance of motor equipment	.01
Total	$.0285

This compares favorably with the best that has been done with electric motors. The storage capacity for a run of 17 miles would be 45 cu. ft.

Controlling the Car.

The Hoadley-Knight motors are controlled by varying the cut-off as well as by the throttle, the two being operated simultaneously. This method of controlling is adopted because it not only gives the highest efficiency, but also gives the greatest range of power. A car can be started with a

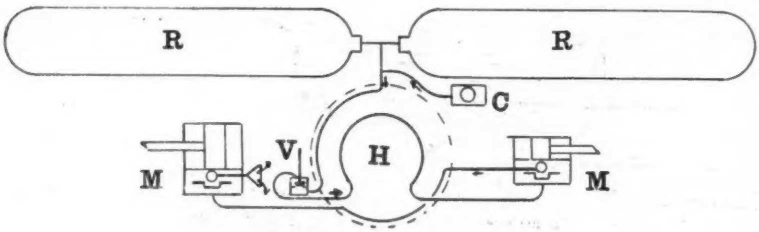


Fig. 3.—Diagram showing Flow of Air.

Traction and Consumption of Air.

The motors are capable of slipping the wheels on a dry rail under a weight of 30,000 lbs., and are therefore as powerful as the heaviest electric motor equipment. The total weight is little, if any, more than that of an equally powerful electric equipment, and the rigid weight on the axle, to which maintenance of track is mostly charged, is considerably less.

The air consumption of these cars varies from 30 lbs. to 40 lbs. per car mile, for a 34 ft. car of the Broadway type. About 11 lbs. of air can be compressed to 2000 lbs. per square inch per horse power hour. The cars require therefore, on an average a little over 3 h.p. hours per car mile, which in a modern compressor, running on a steady load and pumping into a reservoir of ample capacity, can be produced, it is claimed, for

promptness only limited by the friction of the wheels on the rails, or may be started with almost imperceptible acceleration. In common with other air cars, the start is easy and free from jerks.

A forward movement of the single controller handle starts the car and the propelling force is proportional to the distance that the handle is moved from its starting point, so that any degree of acceleration can be obtained. A backward movement to the starting position brings the valve to a minimum cut-off and closes the throttle. A still further backward movement reverses the motors and opens the throttle to back the car. The inventor claims that anything less simple than this is not feasible, or indeed safe, for street car work, and they point out as sustaining this view, that the only successful electric controllers have

been substantially as simple. Of course, with an electric motor the reversing handle has been kept separate, as it is undesirable to reverse an electric motor, but with an air motor there is no objection to reversing, and there is therefore no need of more than one handle on this account.

Heating.

The inventors have made a large and exhaustive series of experiments on the subject of the heater. They have tried all the known forms. Their first experiment with the Mékarski heater, which is the one generally in use on air cars and in which the air is made to pass up through hot water, proved to them that such a method is liable to bring excessive quantities of water over into the motors, when heavy demands are made upon the air. They also found what had not been generally recognized until they announced it, that such a heater, when the contained water is under a pressure exceeding that of the air, runs the motor, practically as a steam engine, with too much visible exhaust and too little air, and that after the pressure of the water in the heater falls below that of the air, practically no steam is generated and the air enters the motor practically dry. Their experiments with dry heaters showed them that the same economy could be obtained with dry heat as with wet, but the heater itself proved objectionable and difficult to regulate. This brought about a return to the hot water heater, but with certain precautions against admitting the air to the water, which proved highly satisfactory.

Storage Reservoirs.

Their experiments with air reservoirs have been probably the most extensive ever made. They have tried laige numbers of each of the five different prominent manufacturers and have experimentally blown up all kinds repeatedly, both with air and water, and find that they are all very much alike, both as regards strength and character of rupture. They are now using the Ehrhardt flasks. It seems to be generally admitted that the air motor would have reached a practical state of perfection much earlier, had it not been for the slow development of the art of making high pressure flasks, which until the last few years were not obtainable of sufficient strength to give the desired capacity within a reasonable space.

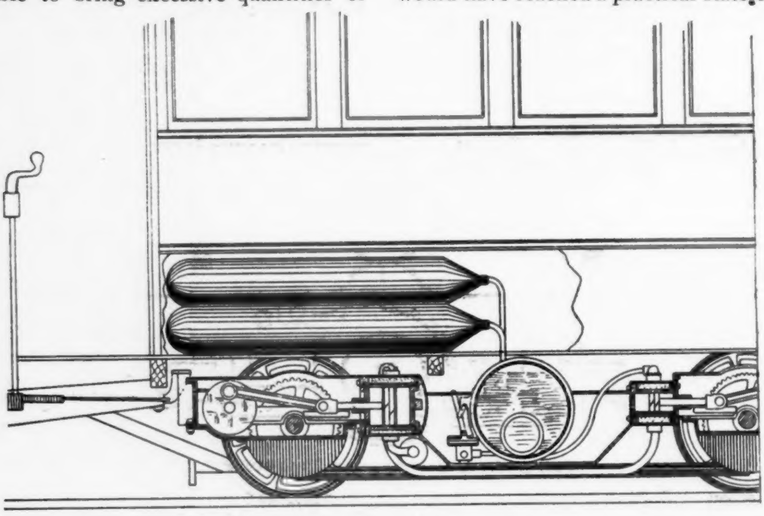


FIG. 4.—SECTIONAL VIEW OF MOTOR CAR.

One of these cars will run 15 miles on a good track on a charge that is restricted to a space under the seats, and this could be even increased to 20 miles by crowding in all the flasks that the space could allow.

As the air pressure in the reservoirs is always limited to that which the compressor can give, and as the reservoirs themselves are capable of withstanding nearly three times this pressure, it will be readily seen that the element of danger is practic-

ally eliminated. There is no possible way in which the air pressure can be increased to the bursting pressure of the flasks. Furthermore, they are protected by a safety pop set up to open at a pressure slightly above that given by the compressor. There is no deteriorating influence incidental to their use. There has never been an explosion with any of these flasks by air, except when premeditated, and only then with the greatest difficulty and with apparatus especially constructed at great expense to bring the required force into play. Every flask is tested to 2½ times its working pressure before being used. Steam boilers are only tested 1½ times the working pressure.

Comfort and Appearance.

The placing of the motor in the middle of the axle and the driving of the axle in the middle, by means of the gear, does away with all lateral oscillation, so common in side rod motors.

The car presents an appearance like that of an electric car without the trolley accessories, and it is claimed to accelerate as quickly, to run as fast, to be as free from vibration, start with greater ease, stop with greater promptness (owing to lack of momentum of armatures) and to possess in general all the advantages of the electric car, without any of its disadvantages.

It is true that every two hours the cars must be charged, but this is done in two minutes and at the end of the line, where it does not inconvenience the passengers, and therefore, so far as the traveling public is concerned, is attended with no disadvantages. To the street railway man it means practically almost no additional expense, as in general a wait of at least two minutes is made at the end of the line.

Common Advantages.

As compared with the storage battery car, which in its absence from dependence upon a distributing system the air motor resembles, the latter is claimed to possess the following advantages :

1. Its storage cells cost very little, comparatively.
2. They are a permanent investment, requiring practically no repairing.
3. The reservoirs can be charged in two minutes instead of six hours.
4. An exhaustion of the battery does not injure it (as with the sulphating of the electric battery).
5. The weight is about one-half.
6. There is no odor.
7. There is no corrosive liquid to slop over, or injure operatives' hands.
8. In case of necessity it can be charged along the line without leaving the line.

Barring fuel burning motors, which seem to be by common consent ruled out of the sphere of street service, compressed air stands alone as the only available stored force, which suffers no loss or deterioration while stored, which is instantly available, which requires no skill to utilize it and which is absolutely free from any offensive products. It is due to these practical features that compressed air has been so successful as a transmitter of force in mining work and air brakes, and the same advantages, it is believed by its promoters, will bring about its very general adoption for propelling vehicles.

The expense of installing this system does not differ materially from that of the electric trolley system. The compressed air power plant can be installed for the same amount as an electric power plant, and the cars, while costing somewhat more than the trolley cars, are more than offset, it is claimed, by the expense of the trolley line itself. As compared with the underground trolley, there is, of course, a saving of the interest and maintenance of the conduit, a sum which would in itself exceed in many cases the whole motive power expense of the compressed air car.

Air Compressors.

Orders have been given for air compressors with four stage single acting air cylinders and intercoolers. They are to be driven by a vertical cross compound condensing Reynolds' Corliss engine, built by the E. P. Allis Co. The compressing cylinders are to be set underneath the engine and are to be built by the Ingersoll-Sergeant Drill Co. The initial cylinder is to be 46" diam. by 60" stroke.

The compressed air automobile illustrated on the outside cover of this issue is a production of the Pneumatic Carriage Co., Postal Telegraph Building, New York, and was developed by Mr. A. H. Hoadley. This carriage is manufactured at the works of the American Wheelock Engine Co., Worcester, Mass., and has been operated in that city for the past two years. It has also been operated many times in the streets of Washington, D. C., and is supposed to be the only automobile of any description yet manufactured capable of ascending a 15 per cent. grade. Other developments are in progress in this same line which we will speak of hereafter.

LIQUID AIR.*

BY

WALTER H. DICKERSON, M. E., '96.

Through the kindness of Mr. Charles E. Tripler, of New York, the Alumni Association was afforded an opportunity at the mid-winter meeting of witnessing some experiments with liquid air. It has been the good fortune of the writer to have been associated with Mr. Tripler for nearly a year past, and as a member of the Alumni Association, it was with pleasure that he came before them as Mr. Tripler's representative, and endeavored in the limited time available to give them some account as to the production of liquid air, its principal characteristics, and some idea of the great possibilities attending its practical application on a commercial scale.

A few remarks at this point upon the conditions necessary for reducing gases to the liquid state, will probably aid the reader to more clearly understand the matter that follows.

All matter is capable of existing in three states, gaseous, liquid and solid, due to its temperature, pressure and volume. If we compress a gas, we increase its density, but as long as the temperature is above a certain point, it will not liquefy. If, however, we reduce the temperature of a gas to a certain point, it will liquefy at a certain pressure and at a less pressure if the temperature is carried lower. This temperature, at which a gas begins to liquefy, is known as its critical temperature, or point. All gases possess a definite fixed critical temperature, at or below which they will liquefy, and above which, they cannot be liquefied, regardless of the pressure applied. Air at the ordinary temperature, has been compressed under fully 4000 atmospheres of pressure per square inch, without liquefying. Oxygen gas, at 17 degrees Centigrade compressed by 4000 atmospheres per square inch, reaches a density of 1.25, but is still in the form of a gas. The following is a table prepared by Prof. Dewar in the *London Engineer*, giving the density of some gases, at the temperature of 15 degrees Centigrade, and at a pressure of 3000 atmospheres per square inch:

	Density of gas at 3000 atmospheres per sq. in.	Density of liquid at boiling point.
Oxygen	1.1034	1.124
Nitrogen	0.8259	0.885
Air	0.8820	.94
Hydrogen	0.0879	

*Reprinted from *The Indicator*.

Thus, we see that it is possible to have a gas denser than its liquid. The limiting density of hydrogen is 0.12. The existence of "critical temperatures" was discovered by Dr. Andrews of Scotland. All liquids possess, below their critical temperatures, definite fixed boiling points, for definite fixed pressures. In the case of air the boiling point under atmospheric pressure is — 191° Centigrade or 312° Fahrenheit. At this point, gaseous air liquefies and remains in the liquid state at ordinary atmospheric pressure, so that air can be changed into a liquid form by cold alone. A glass of liquid air, exposed to the atmospheric air, will receive heat from the warm atmosphere, which will tend to evaporate it, but the portion that evaporates, by absorption of heat energy, keeps the remaining liquid cool; consequently, a jar of liquid air will take a considerable time to evaporate.

Mr. Tripler has been engaged in researches in high pressures for the liquefying of gases, for a number of years, having spent all his time and a great deal of money in this work. During his researches, he devised a simple and economical apparatus for the liquefaction of gases. Although Mr. Tripler's name has not been before the public until very recently, outside of a limited circle interested in his work, his investigations have developed many important results.

The work of the European scientists, in the practical liquefaction of gases, has been chiefly in the following direction:

Starting with a very easily liquefiable gas, as carbon dioxide, the cold produced by the evaporation of its liquid, was used to refrigerate and liquefy a less easily liquefiable gas, under high pressure (such as ethylene for example) and the evaporation of the liquid ethylene, was in turn used to refrigerate and liquefy one of the so-called permanent gases such as oxygen. As the reader can readily conceive, it was an elaborate and necessarily expensive plan, as all these gases had to be compressed to a high pressure.

But, with the apparatus devised by Mr. Tripler, all that is necessary to produce liquid air is gaseous air, under a pressure from 2000 to 2500 pounds pressure to the square inch. The liquefying apparatus proper consists simply of a series of coils of pipe arranged in several concentric cylindrical compartments in the two large "liquefiers" shown in the diagram on the next page. The coils of pipe, which are capable of withstanding high pressures,

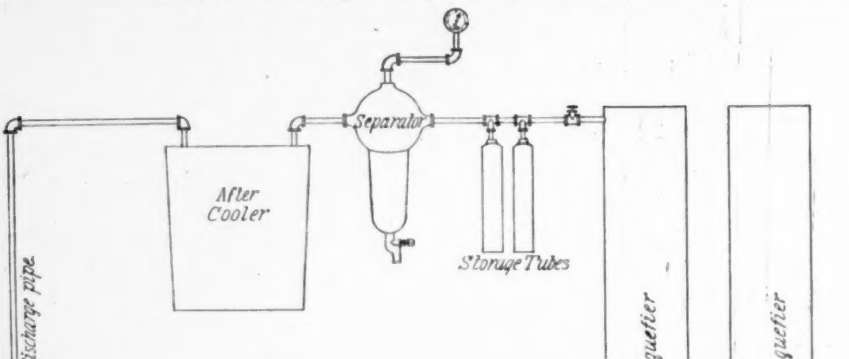
TABLE I.

Number of line.	Substance.	Symbol.	Critical Temperatures. Deg's. Cent.	Critical Temperatures. Deg's. Fahr.	Critical Pressure. Atmos.	Tem. of Saturated Vapor at atmospheric pressure. Deg's. Cent	Tem. of Saturated Vapor at atmospheric pressure. Deg's. Fahr.	Freezing Point. Deg's. Cent.	Freezing Point. Deg's Fahr.	Pressure at which freezing point was determ'd mm.	Density of Gas.	Density of liquid at Temperature given.	Color of Liquid.
			Physical Constants.										
1	Water	H_2O	365	689	200	100	212	0	32	760	.....	1 at .4°C.	Colorless.
2	Hyd. Selenide.	H_2Se	185	365	91	— 41	— 41.8	— 68	— 90.4	....	40	....	"
3	Ammonia.....	NH_4	130	266	115	— 33	— 27	— 77	—107	....	8.5	0.6364 at 0°C.	"
4	Propane	C_3H_6	97	206.6	44	— 45	— 49	Still liquid at —151° C.		....	20.95	....	"
5	Acetylene	C_2H_2	37	98.6	....	— 85	—121	— 81	—113.8	950	12.97	....	"
6	Nitrous oxide.	N_2O	35	96	75	— 89	—128	—115	—175	760	21.99	....	"
7	Ethane	C_2H_6	34	93.2	50.2	— 93	—135.4	Still liquid at —151° C.		....	19.97	....	"
8	Carb. dioxide	CO_2	31	88	75	— 80	—112	— 56	— 69	760	21.94	0.83 at 0°C.	"
9	Ozone	O_3	....	....	....	— 93	—135.4	.....	.....	....	23.89	....	Dark blue, easily exploded.
10	Ethylene	C_2H_4	10	50	51.7	—102	—150	—169	—272	. .	13.97	....	Colorless.
11	Methane......	CH_4	— 81.8	—115.2	54.9	—164	—263.4	—185.8	—302.4	80	7.98	0.415 at—164°C.	"
12	Nitric oxide..	NO	— 93.5	—135	71.2	—153.6	—254	—167	—369	138	14.98	....	"
13	Oxygen	O_2	—118.8	—182	50.8	—181.4	—294.5	.....	.....	....	15.96	1.124 at—181.4°C.	Blue.
14	Argon	A	—121	—185.8	50.6	—187	—304 6	—189.6	—309.3	....	19.9	about 1.5 at—187°C.	Colorless.
15	Car. monoxide	CO	—139.5	—219.1	35.5	—190	—310	—207	—340.6	100	13.96	....	"
16	Air	..	—140	—220	39	—191.4	—312.6	.....	.....	....	.....	0.933 at—191.4°C.	Light blue.
17	Nitrogen	N_2	—146	—231	35	—194.4	—318	—214	—353.2	60	14.01	0.885 at—194.4°C.	Colorless.
18	Hydrogen	H_2	—234	—389	20	—243	—405	.....	.....	....	1	....	"
19	Helium	He	....	...	....	Below —264	—443.2	.....	.....	....	2.02	....	

Reference for data in this table will be found on the next page.

terminate in a specially designed expansion valve and an orifice. The high pressure air entering the liquefier, passes through the coils until it reaches the expansion valve and orifice. Here, the air is expanded in the expansion chamber to very nearly atmospheric pressure. The air, in expanding from the high pressure of 2500 lbs., is reduced in temperature, and this cold expanded air in passing over the coils from which it has just issued reduces the air under high pressure therein contained to so low a temperature that it is in part liquefied. With this apparatus, liquid can be drawn off within fifteen minutes from the time of opening the expansion valve. The method of continuously cooling the incoming air by passing the cool expanded air back over it, as above described, was discovered by Mr. Tripler, in the winter of 1889 and 1890.

Within the last year or two, certain men in Europe have claimed this apparatus as original with them, but their claims as inventors of this apparatus are easily disposed of by the fact that the apparatus, which they are at present using, is almost identical with that which was patented in England by Mr. Tripler over five years ago, and also by the fact that the patent examiners have given him a priority of three years over all others in the use and application of apparatus involving the principles referred to.



It is a significant fact that, with the apparatus first brought out by these claimants, it required 17 hours to produce liquid air, but the time has recently been reduced by them to two or three hours. Another significant fact is that these same claimants did not bring out their apparatus until after Mr. Tripler had filed his applications for patents in England.

Mr. Tripler was assured a few years ago

REFERENCES FOR DATA GIVEN IN TABLE I.

Lines 2, 4, 7, 9, 10, 11, 12, 13, 15, 16 and 17 are given by Olszewski in *Philosophical Magazine*, February, 1895.

Lines 1, 3, 6 and 8 are given by Prof. Linde in *London Engineer*, Nov. 13, 1896.

Line 18 is given by Olszewski in *Philosophical Magazine*, 1895. Calculated.

Line 19 is given by Olszewski in *Annalen der Physik und Chemie*, 1896. Calculated.

Line 5, Critical temperature, given by Ansdell in *Proceedings Royal Society*, Vol. 29, p. 209, 1879. Other data on this line given by P. Villard, *Comptes Rendus*, Vol. 120, p. 1262, June 10, 1895.

by certain scientists, that it would be impossible to produce liquid air according to his idea. Notwithstanding these discouragements, he has by patient persistence, accomplished it, and demonstrated that his method was effective.

The power plant for the production of high pressure air, in Mr. Tripler's laboratory, consists of an ordinary tubular boiler, and a three stage straight line Norwalk compressor. The principal dimensions of the compressor are as follows:

Diameter of steam cylinder...	16	inches.
Diameter of piston rod........	2½	"
Stroke of piston	16	"
Diameter of intake air cylinder.	10½	"
Diameter of piston rod, head end	2½	"
Diameter of piston rod, crank end......................	1 13/16	"
Diameter of intermediate cylinder	6⅝	"
Diameter of piston rod........	1 13/16	"
Diameter of high or 3rd stage air cylinder	2⅝	"
Stroke of all air pistons.......	16	"

Steam pressure carried is from 85 to 90 pounds per square inch.

The cylinders are arranged in tandem, all on the same bed, and are in the following order: Steam cylinder, intake air cylinder, intermediate air cylinder and high or third stage air cylinder. The steam end is a simple steam engine, with adjustable cut-off Meyer valves.

The air is led to the compressor through a pipe, which extends above the roof of the building, in order to get clean air free from dust. Before entering the compressor, the air passes through a washer, which washes it free of dust and saturates it with water. The air enters the intake cylinder, which is double acting, where it is compressed to about 65 lbs pressure to the square inch. It then passes through an inter-cooler, and is reduced to the ordinary atmospheric temperature, by means of water circulated through the pipes in the inter-cooler. It then enters the intermediate cylinder, which is single acting, and is compressed to about 400 pounds pressure From here, the air is discharged into the second inter-cooler, where it is again cooled by means of the water circulation to the ordinary atmospheric temperature. It then enters the high pressure or third stage air cylinder, where it is compressed to the discharge pressure of from 2000 to 2500 pounds pressure per square inch. After passing through an after-cooler, to reduce its temperature again to that of the atmosphere, the air passes through a separator, where all the moisture, oil, dirt, etc., are removed from it, and from there, passes to the storage tubes.

From the storage tubes the air under high pressure passes to the liquefying apparatus and in from twelve to fifteen minutes from the time of starting, liquid air can be drawn off from the apparatus through a discharge pipe at the bottom.

The present apparatus will produce from two to three gallons of liquid air per hour.

The facility with which the liquid is handled and transported is rather remarkable, considering the temperature condition necessary to maintain it in its liquid form. It has been transported in three and four gallon quantities to Lynn, Mass., Philadelphia, Baltimore and Washington, with a loss, from evaporation, of from 25 to 30 per cent. The receptacle in which the air is carried is nothing more or less than a large tin or copper can insulated with about three inches of hair felt.

To be continued.

Deaths among caisson-workers have been investigated by Drs. R. Heller, Wilheim Meyer and Hermann von Shrotter, and the results are contained in a paper in the "Centralblatt der Bauverwaltung," for Dec. 18, 1897, written by Mr. L, Brenecke. In 129 deaths among workers in compressed air, 38 men were divers and 91 caisson-workers. These doctors agree with the theory of Paul Bert, of Paris, that the danger lies, not in the high pressure, but in a too rapid reduction of pressure. This is shown by the fact that a sudden reduction from + 0.3 atmosphere to the normal has caused death; while a pressure of + 5.4 atmospheres was followed by no evil results when 3 hours 3 minutes were consumed in reducing this pressure. They agree that in all except exceptional cases, no deaths will occur if 2 minutes are allowed in reduction, for every 6.1 atmosphere in excess of the normal pressure. They also propose a hospital air-lock where pressure of more than + 1.5 atmospheres are to be used, so that the sick may be treated under pressure. Workman should be housed in barracks where they can be kept under medical control.—*Engineering News.*

Men Prominent in Compressed Air Development.

Two conditions are always prominently connected with the development of every new and useful thing, whether it be a machine or the useful application of a new science—men and money. It is usual for us to talk of the lack of means as the excuse for failure to bring a new thing to the paying point, but the right kind of man, the genius to handle each particular subject is of greater importance than money. Good and useful things have been produced by men working practically without means, but money has never built up a good thing without the aid of the man of brains.

Compressed air, though as old as the hills, is a new thing in its usefulness to mankind. This century, and we may also say this decade, is the compressed air era, and yet the useful application of this power has become so general, that we appear to be only beginning to enter this wide field of usefulness. American men and engineers are responsible for a large share of this. French, German and English engineers and professors are greater theorists, and have built for us the foundations on which practical work has been laid. The Popp system in Paris, deficient as it is from our standpoint, has pointed the way to better things. It was this system which first attracted Professor Riedler's attention to compressed air. The writings and inventions of Professor Riedler entitle him to rank at the top among pneumatic engineers. He has been spoken of as the highest authority on pneumatics in Europe.

This title might perhaps be disputed by Professor Unwin, of England, who though less inventive than Riedler, is quite his equal in knowledge of pneumatics, and whose thoroughness and exhaustive capacity for work entitles him to rank among the greatest of living engineers. Professor Kennedy has also taught us much that we know about compressed air.

The readers of this publication will be glad to see the portraits of those who have accomplished so much, and who are already well known by reputation. Our gallery is necessarily not complete, notably so in that it does not contain the picture of Mr. Ebenezer Hill, of Norwalk, Conn. our highest authority on this subject Mr. Hill is a rare combination of the engineer and business man and an inventor who has designed standard machinery. He has been intimately connected with compressed air

B. C. BATCHELLER.

for perhaps twenty-five years, and in the development of the compound air compressor he is entitled to the first rank. Mr. Hill long ago saw the importance of compound compression, and he adhered to it at a time when he stood alone. To-day every engineer who knows anything about the subject recommends compounding, and all makers of the first class furnish compound machines.

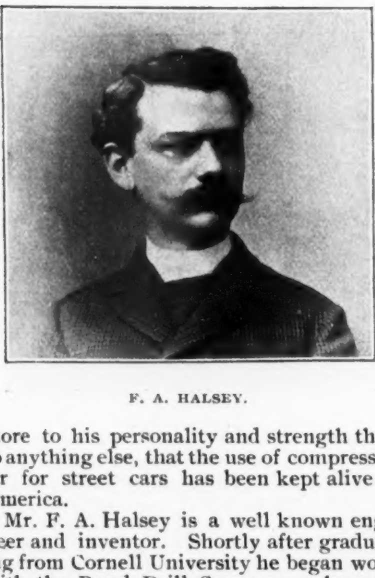
Mr. A. C. Rand, of the Rand Drill Company, is no less prominent in the useful development of compressed air machinery than in his personal modesty, which is our only excuse for the absence of his portrait in this gallery. Mr. Rand is best known in connection with his company, and the machinery which he has developed and introduced throughout the world; he

HENRY D. COOKE.

is also known in the Patent Office, and as the author of "Uses of Compressed Air."

Mr. B. C. Batcheller has been called the Edison of pneumatic sciences. He is, as his portrait indicates, a young man of determination and ability. He is best known in connection with the pneumatic despatch system of the Batcheller Pneumatic Tube Company, which has been adopted by the United States Government. The details of this system, designed by Mr. Batcheller, show that practical originality which usually denotes the successful mechanical engineer.

Mr. H D. Cooke has fought compressed air battles as a gallant knight: Compressed air has been his shibboleth. His work has been mainly of a business nature in connection with the promotion of pneumatic traction companies, and it is probably due



F. A. HALSEY.

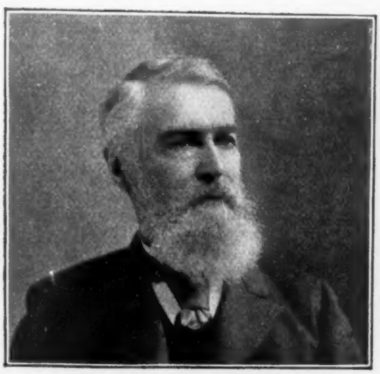
more to his personality and strength than to anything else, that the use of compressed air for street cars has been kept alive in America.

Mr. F. A. Halsey is a well known engineer and inventor. Shortly after graduating from Cornell University he began work with the Rand Drill Company, where he invented the "Slugger" rock drill. Among other things he has invented a mechanical valve motion for air compressors and a pneumatic pump. He has published two works, "Slide Valve Gears," now in its fifth edition, and "Locomotive Link Motion." His paper entitled "The Premium Plan of Paying for Labor," read before the American Society of Mechanical Engineers in 1891, has been widely quoted. He is, perhaps, our best authority

ROBT. HARDIE.

on valves. He is a close student, thoughtful and accurate and an acknowledged authority on pneumatics.

Mr. Robert Hardie, the inventor of the Hardie Air Motor, is a Scotchman by birth, though in all other respects an American. Air, especially in its use for traction, has been Mr. Hardie's hobby. He designed the motor which was used on the elevated road in New York in 1879, and has recently built air motors for street car work. Mr. Hardie had much to do with the design of the De Lavergne Refrigerating Company's machinery: His mechanical ideas are marked by much individuality, the element of simplicity being prominent. It is doubtful if any one has had as much experience as Mr. Hardie in pneumatic traction, and he is an acknowledged authority on the subject.



GEN. HERMAN HAUPT.

GARDNER D. HISCOX.

General Herman Haupt is a well known engineer. Graduating from West Point as a military engineer, the General has had a most extended career in field work, railroad construction, bridge work, as professor of mathematics and civil engineering, general superintendent and chief engineer of railroads, etc. His attention was first attracted to compressed air in 1879. Since then he has been identified with pneumatic traction, as president of the General Compressed Air Company. He has published several works, among them "General Theory of Bridge Construction," and "Haupt on Motors."

Mr. Gardner D. Hiscox, is a distinguished hydraulic and pneumatic engineer, and is at present on the staff of the *Scientific American*. Mr. Hiscox has had a most extended experience in mechanical construction, is very fertile in expedients and has a fund of information at his fingers' ends, based on practical contact with work. As an engineer he combines the theoretical and the practical, and is well posted and a safe adviser on pneumatic and hydraulic subjects.

J. H. McCONNELL.

Mr. J. H. McConnell is the efficient superintendent of motive power of the Union Pacific Railroad at Omaha, Neb. His paper read before the Western Railroad Club (COMPRESSED AIR, Vol. I, No. 2) showed a knowledge of the practical application of air, which has entitled him to rank as one of the most useful students of this subject. Mr. McConnell saw the possibilities that were dormant in compressed air, and he went to work to develop machinery for its use. This he has done in a most extended way on the Union Pacific road.

R. A. PARKE.

Mr. R. A. Parke, is a well known mathematician and engineer, young, able and progressive. He is especially prominent among railway men, because of his connection with the Westinghouse Air Brake Company. He is a recognized authority on compressed air and especially in connection with air brake service. Mr. Parke has designed and patented a system of air brake traction which has been worked experimentally at Albany, N. Y. As an inventor he is extremely conservative, but for this his traction system might have been pressed forward by capitalists. A paper read by Mr. Parke before the New York Railroad Club in 1894, entitled "Economy in Compressed Air Transmission for Commercial purposes and for Air Brake Purposes," has

been widely quoted and is an able contribution to our literature on this subject.

Mr. William Prellwitz is in charge of the engineering department at the shops of The Ingersoll-Sergeant Drill Company. His training in connection with air compression, especially in the design of pneumatic machinery, has been thorough and extensive. Engineering comes natural to him, and he belongs to that class of thinkers on the subject, whose ideas inspire confidence Mr. Prellwitz thinks to the bottom of every subject brought to bis attention; a ready and expert free hand draughtsman and one of our best authorities on pneumatic engineering. His paper entitled "Compressed Air: Its Production, Transmission and Use," published in Vol. II., No. 7, of COMPRESSED AIR, is a compendium on the subject and an

WILLIAM PRELLWITZ,

education to a student of compresssed air literature.

Mr. Whitfield P. Pressinger is the efficient Secretary of the Clayton Air Compressor Works. He has written several magazine articles on compressed air, and his connection with the Clayton Company has given him a wide experience in pneumatics. It has been mainly through Mr. Pressinger's active management that the Clayton Compressor is so widely known.

Mr. Frank Richards stands at the top among pneumatic engineers. A voluminous writer on the subject, clear and interesting in his style and combining the theoretical with the practical. Mr. Richards is a trained mechanic, having been at one time the superintendent of the shops of the Ingersoll-Sergeant Drill Co.

WHITFIELD P. PRESSINGER.

He is at present associate editor of the "*American Machinist.* His book on "Compressed Air" has had a large circulation, and contains more information on this subject than any other American publication. Personally Mr. Richards is of an extremely modest nature, popular with all his associates and a safe consulting engineer.

Mr. Edward A. Rix is better known on the Pacific coast than in the east. He has been intimately connected with compressed air during most of his business life. Mr. Rix is versatile and clever. As an inventor he has produced the Rix Drill and Air Compressor; his best work, perhaps, being the air plant designed by him for the North Star Mining Company, Grass Valley, California. Mr. Rix has made some interesting and useful contributions to compressed air literature, among them

FRANK RICHARDS.

EDWARD A. RIX.

"Rix Engineering Pocket Book," and several magazine articles.

Mr. Henry C. Sergeant is well known in connection with The Ingersoll-Sergeant Drill Co. Among his inventions are the Ingersoll Eclipse and the Sergeant Drills, the Sergeant Coal Cutter and the Ingersoll-Sergeant Air Compressors. He first attracted attention in 1861, when by Act of Congress the United States Government gave him $10,000 for a marine engine regulator. He was at that time twenty six years of age. All his inventions have been in the line of steam, gas and air machinery. The Patent office records bear evidences of Mr. Sergeant's fertility as an inventor,

HENRY C. SERGEANT.

His work always bears the mark of practical simplicity, combined with economy of construction and operation.

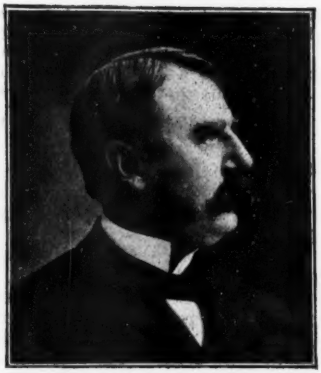
Mr. J. W. Thomas, Jr., is assistant general manager of the Nashville, Chattanooga & St. Louis Railway. He designed and has successfully applied an original pneumatic system of handling switches and signals, described in Vol. II., No. 8, COMPRESSED AIR.

Mr. Charles E. Tripler has recently attracted much attention in connection with liquid air. He has been engaged in researches in high pressures for the liquefying of gases for a number of years, having devoted all his time and a great deal of money to this work. During his researches

J. W. THOMAS, JR.

he devised a simple and economical apparatus for the liquefaction of gases, his investigations on this subject having developed many important results.

Mr. F. C. Weber is an able mechanical engineer, at present employed by the Rand Drill Company. He is a graduate of Cornell University, where he attracted attention by a graduating thesis on compressed air, in which was embodied original research. Mr. Weber has a straight mind, is a born mathematician and an authority on pneumatics. His address before the Engineering Society of Columbia College,



CHAS. E. TRIPLER.

entitled "Compressed Air as used for Power Purposes," was published in the early issues of this paper.

F. C. WEBER.

To Ring Chime Bells.

Work is progressing on the proposed ringing of the chime bells of St. Patrick's Cathedral, New York, by compressed air. Mr. Hertford C. Champ is the inventor of the system adopted. The keyboards will be in the sacristy of the church, 600 feet from the bells. The valves of the cylinders will be operated by electricity and the clappers will be moved by the piston attached to them. The air compressor will be driven by electricity. There are nineteen bells in all, weighing from 300 to 6,000 pounds each.

Manhattan Elevated Railroad Shops.

The power which is extending its range in railroad fields with a force and vigor of which we have no recorded precedent, is compressed air, which is becoming every day more and more closely linked with practical usefulness, and the reason therefor is not far to seek, and is a short tale soon told.

Compressed air and pneumatic apparatus of the higest types, are the embodiments of inventions made by mechanicians who grasped the compressed air proposition with one hand, and the requirements of industries with the other, incorporating them into the moulds that fashioned the compressors and tools which are at work to-day in every part of the world. One of the most conspicuous features in the progress of compressed air apparatus and pneumatic tools is their rapidly extended use in railroad shops, under numerous novel conditions and forms. A notably well conceived and carried out installation of the latest type of compressed air service is that in the shops of the Manhattan Elevated Railroad Company, which covers two city blocks in the Borough of Manhattan, bounded by East 98th and 99th Streets and Third and Fourth Avenues.

The elevated roads comprised under the Manhattan management, have been for a quarter of a century, a great factor in the upbuilding of the new west and east sides of what are now the Boroughs of Manhattan and Bronx. In 1873, the then existing elevated road was a light structure, single track with sidings, extending from Rector to West 34th Street. The power was transmitted from stationary engines, to endless chains clutched by the cars. The system was crude, when measured from the standpoint of to-day, but nevertheless, the road

BORING HOLES IN WOOD.

sprang into immediate popularity, and its prosperity led to the great extension commenced in 1876, which stretched miles of tracks over territory in great part devoted to agriculture, and as sparsely settled as counties of the state bordering upon the Adirondack region. It is now 20 years since the roads were completed to the Harlem river and beyond, and the strongest evidence of the road's success in building up the city is the indisputable evidence that since 1876, there has been built upon land from 59th Street to 176th Street, and from river to river, homes, shops, factories and institutions which house a larger population than is enumerated in the combined populations of Boston and Baltimore.

The Manhattan elevated system holds the world's record for frequency of trains, and passenger traffic, per mile of track. As an illustration of the volume of traffic, it may be said, that the system conveys more passengers than all the railroads which ply between the Potomac and Rio Grande rivers.

The following figures shows the enormous traffic of one year.

Train, Car and Engine Mileage and Passengers Carried, Fiscal Year ending June 30th, 1897.

	Train Miles.	Car Miles.	Eng. Miles.
Branches . .	120,130.78	184.558 36	120,130.78
Main Lines .	9.790,834.60	42,996.973.42	10,548.448 28
Total	9 910,965.38	43,181,531.78	10,668,579.06

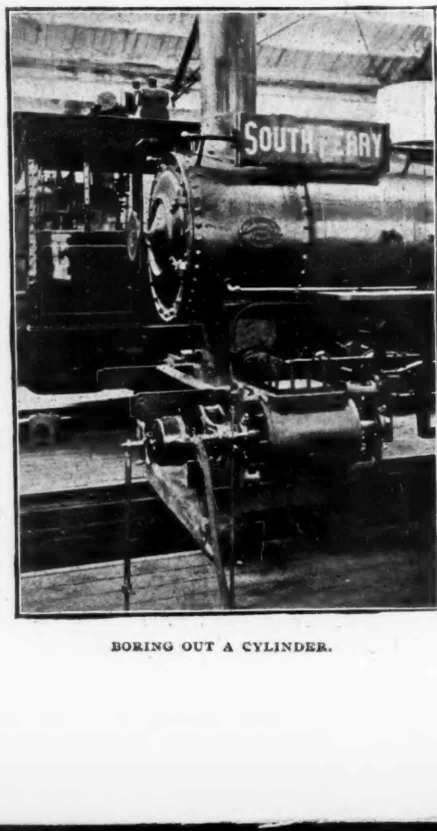
Total number of Passengers

All lines 182,964 851

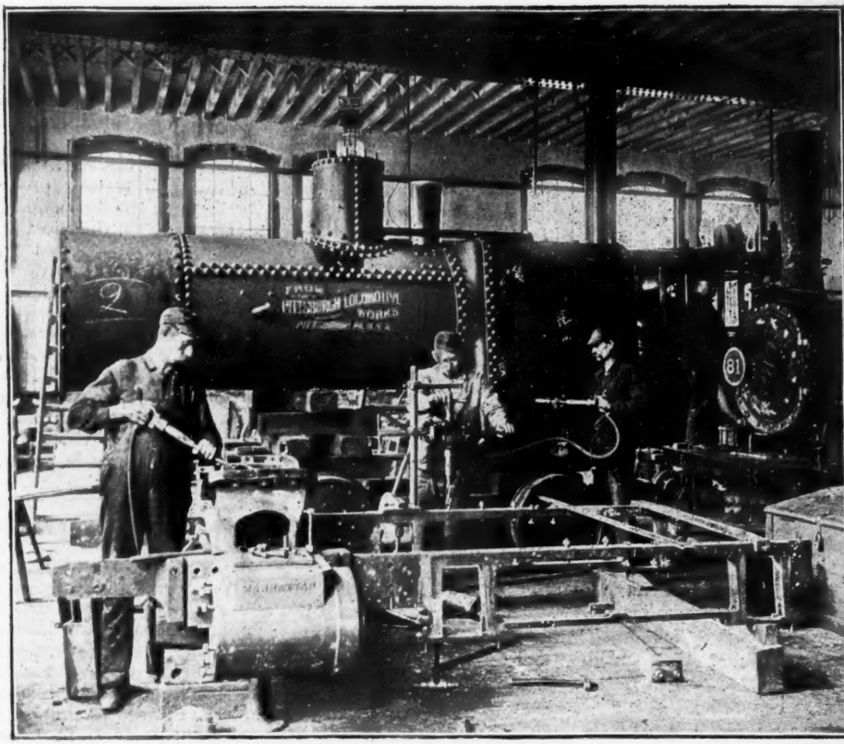
The need of improved appliances suitable for handling expeditiously the vast equipment of the road was quickly appreciated by Mr. W. J. Fransioli, General Manager of the Manhattan Elevated Railroad, and one of his earliest acts on assuming management was to take up the compressed air feature. Previous to that time it had not been used at all. By his kind permission we recently had the pleasure of visiting the Manhattan shops for the purpose shown herein.

For the information relative to the plant we are indebted to Mr. M. McNally, Master Mechanic.

The air compressor is situated in the boiler and engine room, a separate building, adjacent to the blacksmith, boiler and machine shops. The type is an Ingersoll-Sergeant



BORING OUT A CYLINDER.

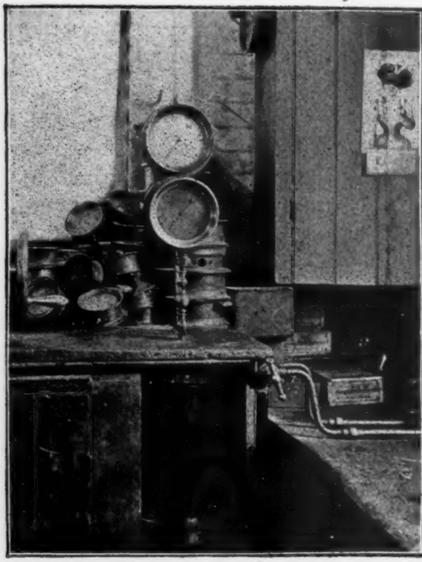


CHIPPING AND DRILLING WITH HAESELER DRILLS AND BOYER TOOLS.

From the reservoir the air is conveyed in 600 feet of three inch, and 900 feet of two inch mains, to the various shops. In one line of main pipe the extension is underground in a public street, and then overhead for distribution in a shop 400 feet from the compressor, but there is no drop in potentialty in any of the smaller supply pipes deflected from that main. In each shop there are either batteries or single air tanks conveniently placed for access and distribution to the best advantage. A great many air hoists are used, and one is in course of construction for hoisting lumber from the yard to the upper stories of the wood working shops, which will hoist about 3,000 pounds or less, 26 feet.

Several pneumatic cranes are in use; one recently intalled, enables one man in one minute, to perform work that formerly required two men four minutes. In the boiler shop pneumatic tapping, screwing and drilling machines, perform varied operations with high velocity and accuracy. In form the machine is a rotary miniature engine, with a short cylinder fitted with a circular piston, internally tangent to the cylinder; the axis of the piston being parallel with the cylinder. A sliding diaphragm of brass divides the cylinder into two equal parts, air admitted behind the diaphragm, causes it to revolve until the exhaust passage is reached. The speed of the piston is controlled by gearing. This ingenious machine is used for tapping and screwing staybolts, reaming and drilling out boiler tubes, and drilling of several descriptions. With this machine a good mechanic can roll out 200 boiler tubes on both ends in four hours.

Several rivetters are in use, and in them is noticeable the striking superiority of pneumatic over hydraulic rivetters, in that the pneumatic rivetter makes an initial stroke that is quick and powerful, bonding the rivet and plate into homogeneity, fol-



GAUGE TESTING APPARATUS.

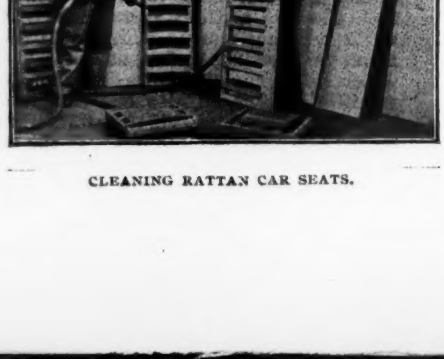
lowing with a secondary blow which upsets the rivet, so that the rivet and orifice are fixed in a perfect union. The pneumatic staybolt cutter has a capacity for cutting off from 1,200 to 1,500 staybolts an hour, according to the diameter of the bolts.

Under the chisel and hammer method which obtains in shops not equipped with compressed air, staybolts are invariably loosened in the sheets, whereas with pneumatic tools, the work is flawless. All caulking performed in this establishment is done with pneumatic tools of especial design for the requirements. Reboring of cylinders while in shop for ordinary purposes.

The hoists for axle lathes and wheel borers are also of designs adapted to the requirements of the work, and are provided with ingeniously constructed gripping, and overhead trolley attachment. One man can lift a wheel to the lathe in two seconds. All the air hoists were made in the establishment; the material being wrought iron pipe, the ends being set with ordinary caps and couplings. The pistons work well, notwithstanding the fact, that in several patterns, the cylinders were not bored out, as is done with hydraulic jacks and hoists, and arrangements are being made for a further extension of work in the direction of hammers, jacks and portable cranes for use in the yards. All cylinders are blown out with air, replacing the steam process, so hot and uncomfortable for the hands. All air is delivered at uniform pressure of eighty pounds, wheresoever required in and out of shops. Other uses besides the foregoing are seen in the air brake bonding and testing processes, the testing of Pintsch gas tanks and pipes to eighteen atmospheres, the boring and cutting of wood, the mixing of paints, and the conveyance of sawdust from the shops through pipes to the sawdust furnace near the boiler house.

All the seats and backs of the car seats are of cane work, and are soon soiled and begrimed with smut and dust in the almost incessant use to which they are subjected to. These are cleansed from dirt and dust wholly by means of compressed air admitted through an 1/8" nozzle secured to flexible connections.

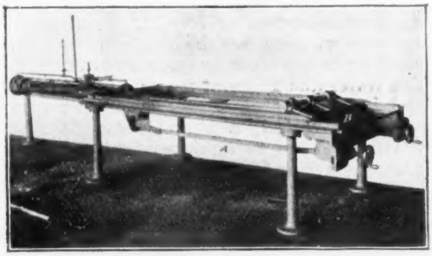
All castings are cleansed by substantially the same process. A short time ago, when preparations were being made for painting the interior of the shops, Mr. McNally decided to free the walls and ceilings from dust by the use of compressed air forced through 1/8" nozzles secured to hose connections. The result of the operations has firmly established the process for future use. This in brief recounts the application of compressed air and pneumatic tools in an extensive plant, which in every respect is in alignment with every progressive movement in mechanic arts that is founded upon correct principles, having for its purpose the production, conservation and practical use of the highest available type



CLEANING RATTAN CAR SEATS.

of power applied through the best tools.

Ere long further additions will be made to the use of compressed air apparatus at this plant, where it is recognized as a mighty power, swift and sure, pulsating with energy that can both push and pull.



The above illustration shows an apparatus which is used in the candy manufactory of Croft & Allen, Philadelphia, Pa. Its purpose is to remove candy from the tops of tables where it has been spread in thin layers to harden. These tables are provided with rollers for easily running about the place. When the candy has become of proper consistency the table is shoved over under the apparatus. It is clamped firmly to the bar A shown underneath. The blade B, which is then at the end opposite (C) to where it is in the picture, is forced forward by means of a piston attached to the blade driving it the entire length of stroke. The blade skims the top of the table, scooping the candy which has adhered very firmly. The result is a great saving of labor. It is all done in a few seconds, whereas before the apparatus was designed, several men were employed to remove the candy. Many tables were required and the limited room was in continued confusion. The apparatus was designed by Mr. Howard A. Pedrick, of the firm of Pedrick & Ayer, Philadelphia, and while it is a special appliance, it is none the less interesting.

We beg to inform our readers that we have on hand a limited number of bound copies of Volume No. 2. COMPRESSED AIR, including the numbers from March, 1897, to February, 1898. Price, $2.00.

In this issue we combine the matter usually contained in two numbers of "COMPRESSED AIR." Our reason for doing so is to enable us to arrange the date of each issue to conform with the usual method of periodicals. Hereafter this journal will be regularly issued on or about the first day of each month and will bear the date of that month.

A most interesting installation of an air compressor, a gasoline engine and a mine hoist, is in operation at the Golden Wave Mine Congress, Arizona. The gasoline engine is a standard Fairbanks-Morse type and is located between the air compressor and hoist. The shaft of the compressor is directly connected to the engine shaft by means of a friction clutch coupling. The engine shaft is extended on the opposite side and connected to the drum of the hoist. The gasoline engine operates both compressor and hoist, air being used to run rock drills. The plant is admirably adapted for small mining operations and other work, and especially useful where ordinary fuel is scarce, owing to the portability of gasoline, and the plant itself. The general eastern agents of the Fairbanks--Morse Co., are Messrs. Patterson, Gottfried & Hunter, New York.

Liquefying Hydrogen.

LONDON, May 11.—Prof. Dewar has succeeded in liquefying hydrogen, which is an unprecedented feat. despite the successes claimed by some theorists. Prof. Dewar produced half a wine glass full of the liquid in five minutes. The process is applicable to any quantity. The boiling point of the liquid is 240° below zero, centigrade. Scientific men regard the feat as being of immense importance, apart from its enormous scientific interest. By use of liquid hydrogen, Prof. Dewar has also liquefied helium.—*N. Y. Sun.*

COMMUNICATIONS.

Under this heading will be published inquiries addressed to the Editor of COMPRESSED AIR. We wish to encourage our readers in the practice of making inquiries and expressing opinions.

We request that the rules governing such correspondence will be observed, viz: all communications should be written on one side of the paper only: they should be short and to the point.

LIMA, O., May 11th, 1898.

"COMPRESSED AIR."

Would you kindly give me some information upon the following point?

It is desired to raise water from a well by the "Air-lift" process, the casing of same being 6" in diameter, and surface of water 80 feet below the ground. We wish to know if an ordinary 8" air brake pump can be used to accomplish this, it being necessary to convey the air a distance of 1500 feet from the pump to the well. I presume it will be necessary to place a smaller pipe inside the casing for the purpose of raising the water.

I should like very much to know what is the method of calculation for determining what amount of water, a given amount of compressed air, at a given pressure is capable of raising.

Hoping that I am not imposing upon good nature, I am,

Very truly,

CHAS. H. FRY, JR.

The amount of water pumped by an Air Lift Pump depends upon the number of cubic feet of free air per minute, the height to which the water is raised above its surface and many other conditions under which the Air Lift Pump may operate.

If your Air Brake Pump has 8" x 8" cylinders and runs 120 strokes per minute, the volume of free air compressed would be of course the product of the piston speed by the area of the cylinder from which should be deducted perhaps 20 per cent. for clearance and leakage with this style of pump. This will give 28—20 per cent, say 22 cubic feet of free air per minute.

The formula commonly used for determining the amount of water raised with a given amount of free air is as follows:

$G - \frac{125A}{L}$ where G equals the number of gallons per minute A equals cubic feet of free air and L equals the lift in feet from the surface of the water to the point of discharge. This would be for your case $\frac{125 \times 22}{80}$ equals about 34 gallons per minute. This applies only when the submergence equals one and one-half times the lift, or for your case 120 feet of water when lifting 80 feet above the water level, or to the surface of the ground only. As this water level will probably fall somewhat when pumping, the lift will be increased and the amount of water pumped decreased accordingly.

For a 1" pipe line 1500 feet long carrying about 22 cubic feet of free air per minute, the loss of pressure by friction will be about 5 pounds—not an excessive amount. The water discharge pipe should be 2" and the air pipe ¾" or 1". The air pressure will be about half a pound for each foot of submergence, being dependent upon the submergence and not upon the lift.

While you can operate an Air Lift Pump by the use of an Air Brake Pump it is not an economical process. This style of pump uses from 150 to 250 pounds of steam per 1 horse power per hour, where an inexpensive belt driven Air Compressor would run on 40 pounds, and the saving in fuel would pay for the air compressor in a few months. It was recently brought out at a meeting of railroad officials, that if air brake pumps were to be had for nothing, it would pay better to buy air compressors at an extravagantly high price on account of the fuel saving —ED.

COMPRESSED AIR:

We are in receipt of nine numbers and index of Vol. No. 1, and a perusal of the first four numbers has whetted our appetite for the missing numbers five, six and eleven. We sincerely trust you will be able to get us these missing links, as a promised feast should not lack any of the essentials. Can you not see your way to reprint these three numbers? Surely there will be more than our modest demand for them, but if not, can you not give us typewritten copies of the articles appearing therein or in some other way enable us to complete what we are sure will prove a most valuable addition to our mechanical literature? Do help us out in some way.

Sincerely,

UNION BOILER TUBE CLEANER CO.,
A. T. Rowand, President.

NOTE.—We have many requests similiar to the above. Can any one furnish our correspondent with the above numbers of Volume No. 1, July, August, 1896, and January, 1897?—ED.

ALPHABETICAL LIST OF INVENTIONS.

For which patents have been granted on pneumatic appliances. Prepared especially from official records for COMPRESSED AIR,

BY GRAFTON L. M'GILL.

APPLIANCE.	NAME OF INVENTOR.	DATE OF ISSUE.	No.
Air Engines	Anderson	April 16, 1895	537,517
"	Anderson & Ericksson	March 30, 1897	579,670
"	Barbour & Hansen	Oct. 12, 1897	591,584
"	Benster	Nov. 10, 1891	463,092
"	Bercher	April 21, 1896	558,475
"	Bergman	Nov. 10, 1891	463,025
"	Berry	May 11, 1897	582,257
"	Bole	Oct. 26, 1897	592,688
"	Bramwell	July 30, 1895	543,462
"	Brock	Aug. 19, 1890	434,422
"	Chapman	Feb. 24, 1891	447,066
"	Coon	March 10, 1896	555,929
"	Denney	April 23, 1895	538,068
"	Depp	June 19, 1894	521,762
"	Durand	May 9, 1893	497,048
"	Eastman	Dec. 30, 1890	443,641
"	Ericsson	July 8, 1890	431,729
"	Field	Oct. 10, 1893	506,486
"	Fletcher & Huggings.	Oct. 8, 1895	547,718
"	Gibbs	Oct. 26, 1897	592,246
"	Goth	April 13, 1897	580,600
"	Good	May 26, 1896	560,707
"	Good & Marichal	April 28, 1896	558,944
"	Griswold	June 30, 1891	455,201
"	Hall	Aug. 4, 1891	457,272
"	"	Aug. 4, 1891	457,273
"	Hanser & Whittaker	Jan. 3, 1893	489,148
"	Harder	Oct. 14, 1890	438,251
"	Jefferson	Dec. 1, 1891	464,364
"	Martin	June 27, 1893	500,340
"	Metzing	Nov. 18, 1890	441,103
"	Mihsbach & Groeschel	Sept. 1, 1896	566,785
"	Musselman	Aug. 8, 1893	502,860
"	McCalla	Feb. 4, 1890	420,824
"	McKinley	July 30, 1878	206,597
"	"	Jan. 18, 1887	356,146
"	"	Jan. 18, 1887	356,147
"	McTighe	July 7, 1885	321,739
"	"	June 3, 1890	429,281
"	"	" 3, 1890	429,282
"	"	" 3, 1890	429,283
"	Nash	May 22, 1883	278,257
"	Parke	Dec. 7, 1897	594,901
"	Parsons	Nov. 12, 1895	549,741
"	Philpott	March 15, 1887	359,282
"	Pollock	April 28, 1885	316,656
"	Presbrey	Aug. 24, 1880	231,446
"	Reynolds	Aug. 1, 1882	262,119
"	Rider	Oct. 7, 1879	220,309
"	"	July 23, 1878	206,356

ALPHABETICAL LIST OF INVENTIONS.--*Cont.*

APPLIANCE.	NAME OF INVENTOR.	DATE OF ISSUE.	NO.
Air Engines	Rider	Sept. 7, 1875	167,568
"	"	Jan. 5, 1875	158,525
"	"	Nov. 27, 1888	393,663
"	"	Nov. 27, 1888	393,723
"	"	July 13, 1886	345,450
"	"	Nov. 23, 1886	353,004
"	Riley	June 29, 1875	165,027
"	Robinson	Dec. 9, 1884	309,163
"	Robinson	Feb. 3, 1891	445,904
"	Roediger	March 30, 1897	579,654
"	Rogers	May 13, 1890	427,911
"	Rogers	Jan. 2, 1894	511,969
"	Rusk	Aug. 18, 1891	458,070
"	Schnake	Nov. 28, 1876	184,913
"	Schmid & Beckfeld	May 14, 1889	403,294
"	"	Feb. 18, 1890	421,525
"	Schou	Nov. 21, 1893	508,990
"	Serdinko	Feb. 2, 1886	335,388
"	Sherman	March 12, 1895	535,602
"	Sherrill	April 1, 1879	213,783
"	Shilling	June 16, 1885	320,182
"	Smith	Feb. 14, 1893	491,859
"	Stevens	Sept. 16, 1884	305,114
"	"	Oct. 29, 1889	414,173
"	Stewart	May 15, 1894	519,977
"	Tasker	June 7, 1887	364,451
"	Thuemmler	Sept. 28, 1880	232,660
"	"	Oct. 12, 1880	233,125
"	Vivian	Sept. 30, 1890	437,320
"	Walling	Aug. 4, 1896	565,191
"	Ward	Jan. 1, 1878	198,827
"	Weimer	Feb. 23, 1897	577,568
"	Wilcox	Dec. 4, 1883	289,481
"	"	Dec. 4, 1883	289,482
"	" (re-issue)	June 3, 1884	10,486
"	" "	Oct. 7, 1884	10,529
"	"	Dec. 15, 1885	332,312
"	Winchell	April 17, 1888	381,313
"	Wood	Aug. 18, 1885	324,510
"	Woodbury *et al.*	June 8, 1880	228,712
"	"	" "	228,713
"	"	" "	228,714
"	"	" "	228,715
"	"	" "	228,716
"	"	" "	228,717
"	"	Aug. 11, 1885	324,062
"	"	Dec. 1, 1885	331,359
"	"	Dec. 1, 1885	331,361
"	"	Aug. 11, 1885	324,060
"	"	Aug. 11, 1885	324,061
"	"	Sept. 1, 1885	325,640
"	"	Oct. 6, 1885	327,748
"	"	May 28, 1889	404,237
"	Wright	Aug. 13, 1889	408,784

Patents Granted April, 1898.

Specially prepared for Compressed Air from the Patent Office files by Grafton L. McGill, Washington, D. C.

602,877—Air Compressor. Henry C. Sergeant, Westfield, N. J. Assignor to The Ingersoll-Sergeant Drill Co., New York.

This invention relates to the class of compound compressors, or those in which air compressed in one cylinder is transferred to another where it is further compressed. The invention comprises two compression cylinders and corresponding pistons of unequalled calibre arranged in line with each other, on one rod. The piston of smaller calibre, or the high pressure piston, is affixed to the rod, while that of a larger calibre, or low pressure piston, is provided with passages and contains a valve seat. It is so attached to the high pressure piston as to permit an independent sliding movement of the latter within itself. A valve affixed to the smaller piston and rod is adapted to the valve-seat in the larger piston for opening and closing the passages through the larger piston by the movement of the smaller piston. This valve serves also to transmit motion from the high-pressure piston in opposite direction to the piston of low pressure.

602,198—Compressed Air Hammer. Jacob Schmidt, Rio Vista, Cal.

Two cylinders are arranged at right angles to one another and connected by a valve controlled passage. One cylinder is vertically arranged and provided with a piston having a hammer on its end. The second, laterally extended cylinder is provided with a plunger and connected with mechanism whereby air is compressed in said second cylinder. The valve controlling the passage between the two cylinders is operated by connection with a crank or eccentric upon the main operating shaft. The valve is closed until the air in the compressing cylinder has reached any desired tension. Thus the air in the first cylinder propels the piston of the second. Valves and connections regulate or vary the force of the blow of the hammer.

602,473 — Valve for Air Compressor. Frank Richards, New York, N. Y.

The outer casing of the valve is designed to fit in the base of the air compressor, the latter being perforated and recessed. A flange on the bottom of said casing is adapted to enter the recess, while the inner, removable shell of the valve, also having a flange, is arranged to force the flange on the casing against its seat in the recess and to form a joint with the base of the compressor.

603,242—Hydraulic Air Compressor Pump. E. H. Weatherhead, Cleveland, Ohio.

An air compressing chamber having a piston therein, is mounted upon a base, the latter being provided with inlet and outlet ports. A combined inlet and outlet valve is so arranged as to open one of said ports simultaneously with closing the other. A rod is connected with the piston and valve to actuate the latter, while spring actuated mechanism is located in the base and engages the rod to facilitate the action of the valve at the ends of the strokes of the rod.

602,247—Hydraulic Air Compressor. W. F. Stark, New York. Assignor to Standard Pump and Filter Co., New Jersey.

A compression chamber is provided at its lower portion with a water inlet port and a water outlet port opening downward, while a submergeable cup-float is arranged between said ports and adapted to close the water outlet port when buoyed up by the water, and to seat itself directly on and close the water inlet port when it sinks by gravity. This cup-float is of sufficient weight when submerged to prevent the influx of water and is guided in its up-and-down movements by a stem on which it acts.

602,094—Air Brake. J. J. Nef, New York.

A pump and pump-operating mechanism are employed in conjunction with a compound air cylinder comprising two cylinders of different diameters. A piston is located within the compound cylinder and is provided with heads of different diameters which correspond with bores in the compound cylinder. A valve chamber is arranged in open communication with the smaller cylinder and has a port communicating with the larger cylinder and an exhaust port. The valve in said chamber is operated to alternately open and close the larger cylinder to the valve chamber and exhaust by variations in air pressure.

602,170—Air Valve. E. A Rix, San Francisco, Cal.

An air-inlet valve consists of a main shell or casing having an annular valve shell sliding therein. The outer end of the valve shell is provided with a stop collar, while a stop ring for said collar fits into a recess in the outer end of the main shell and is held by the valve stem support. The other end of this valve shell has an integrally formed valve disc with integral radial wings, passages extending through the valve shell between the said wings and just above the valve disc.

601,822—Hot Air Furnace. J. T. Warren, Buffalo, N. Y.

The fire box and smoke pipe are arranged within the hot air chamber and communicate with a series of drums also located in the hot air chamber. A series of diaphrams of less diameter than the drums are centrally arranged within the latter, whereby the heat generated in the fire box has passing contact with the entire radiating surface of the drums. Openings in the diaphrams and dampers operating therewith, produce a direct draft from the fire box to the smoke pipe.

The Clayton Air Compressor Works, Havemeyer Building, New York, for the past three months report a large number of air compressors sold for compressed air operations.

Among the orders of especial interest may be mentioned the plant installed at the Navy Yard, Brooklyn, New York, for supplying pneumatic drills, paint machines and Hammers, and one furnished to the Yarrow Ship Yard, London, for operating pneumatic tools. Another installation of interest is the compressor at the Dunn Building, New York, which supplies compressed air dusting nozzles for cleaning the iron grill work of the elevator shafts. Among the orders now on hand, is a large compressor for the Bath Iron Works, Bath, Me., to operate pneumatic tools.

Lubrication .. Oil Pump.

Used for lubricating Air and Steam Cylinders, and Main Bearings of Shafts on large Hoisting Engines, prevents them from getting hot. When engine stops, cup stops feeding.

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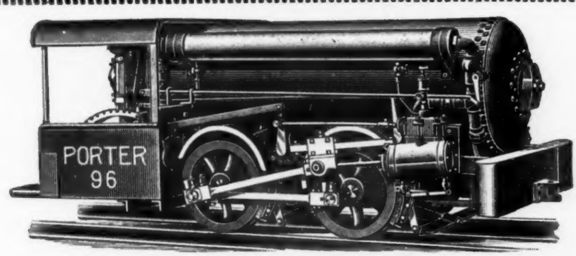

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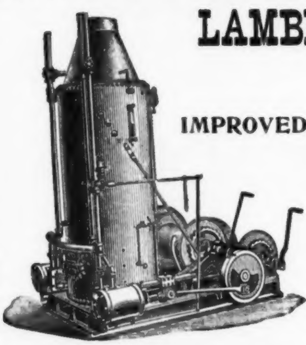
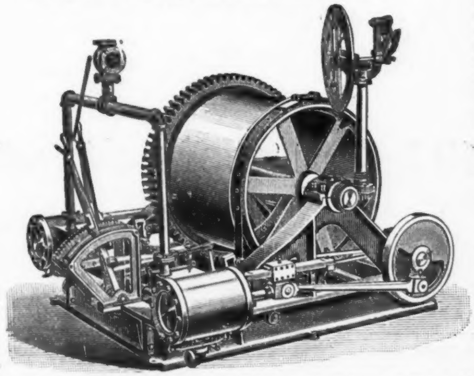
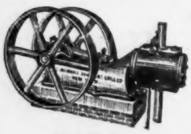
Address mentioning "COMPRESSED AIR."

H. K. PORTER & CO., 540 Wood St., Pittsburgh, Pa.



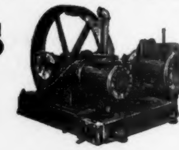




CLASS E.

VARIED SIZES AND TYPES

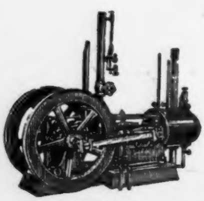
. . . OF . . .



CLASS J.

AIR COMPRESSORS

The types shown here are used in Shops and Mines, or Quarries.
Catalogues show a great variety of Machines for Compressing Air.
Recent orders from Penn. R. R., Cambria Iron Co., Newport News Shipbuilding Co., Etc., Etc.

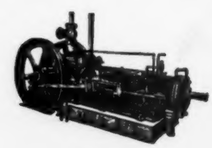


CLASS F.

THE

INGERSOLL-SERGEANT DRILL CO.,

Havemeyer Building,
New York.



CLASS A.

COMPRESSED AIR is used for Operating Rock Drills, Coal Cutters, Pumps, Hoisting Engines and other machinery in mines and tunnels, Air Brakes on Railroad and Street Cars, Switches and Signals, Engines, Hoists, Cranes, Stone Carving and Boiler Calking Tools, Polishing Machines, Riveters, Punches, Hammers, Tapping, Screwing and Drilling Machines, Stay-bolt Cutters, Angle Iron Shears, Wood Bundling Machines and Shop Tools of every description, Oil Fires under Ovens, Furnaces and Boilers and in fifty other applications such as Welding, Annealing, Tempering, Oil Illuminating Lights, Pneumatic Transmission Tubes, Street Railway Motors and Mine Locomotives, Passenger and Freight Elevators, Sheep Shearing Machines and Cloth Cutters, Sand Blast Machines, Pneumatic Gun Carriages, Clocks, Railway Crossing Gates, Automatic Signals, Jacking-up Cars and Steering Gear of Vessels.

Charging Pneumatic Dynamite Guns and Projectiles, Automatic Sprinkler systems for fire protection, inflating Pneumatic Tires and compressing Cotton into Bales.

Tunnel Driving by the Pneumatic Process; Sinking Caissons for Structural Foundations: Pumping Wells by Air Lift Pump method: Conveying and Elevating Acids, Chemicals and other Liquids; Racking off Beer in Breweries; Aerating Water Supplies of Cities, Towns and Villages; Agitating Fluids, such as Asphalt, Lard, Molasses and Chemical Solutions; Mixing Nitro-glycerine; Removing Hose from Mandrels in rubber factories; Testing Tinware, Pipe, Hose, and other manufactured products required to stand pressure; Increasing and Maintaining pressure on Hydraulic Elevators; Sprays of all descriptions, including Physicians', Hospitals', Sanitariums' and Baths; Spraying Solution in the manufacture of silk ribbon; Moving and Elevating Grain, Culm and other material; Cleaning Carpets, Car Cushions, etc.; Unloading Dump Cars; Raising Sunken Vessels; Supplying Divers in Sub-marine Operations; Refrigerating, Ventilating and Cold Storage; Manufacture of various Gases; Disposition of Sewage; and for a large number of other duties in Railroad Shops, Chemical Works and in connection with a wide variety of Experiments and Patented Processes.

We can furnish special types of Air Compressors for every purpose to which compressed air is applied. In writing for proposal, state duty, volume (cubic feet of free air required per minute), and working air pressure desired. Also, state whether a steam, belt or gear actuated compressor is preferred. If to operate by steam direct, state steam pressure available at compressor. If belt or geared, state horse power available for operating compressor.

CLAYTON AIR COMPRESSOR WORKS,

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